CETN-III-16
Revised
11/83

Coastal Engineering Technical Note

SIDE-SCAN SONAR FOR INSPECTING COASTAL STRUCTURES

PURPOSE: Side-scan sonar (SSS) is an effective tool for inspecting the underwater portion of coastal structures. This note discusses SSS methods for inspecting both sloping and vertical-wall structures.

INTRODUCTION: SSS has been used to map the sea bottom and search for submerged objects since the 1960's (Fleming, 1976). Recent experiments by CERC and the Buffalo District have shown SSS to be useful for inspecting both sloping coastal structures (i.e., rubble-mound jetties and breakwaters) and vertical-wall structures (i.e., concrete caissons and timber cribs).

SSS is an adaptation of high-frequency depth sounders. It uses sound energy projected laterally to produce an acoustic image of the sea bottom or submerged structure (Figure 1).

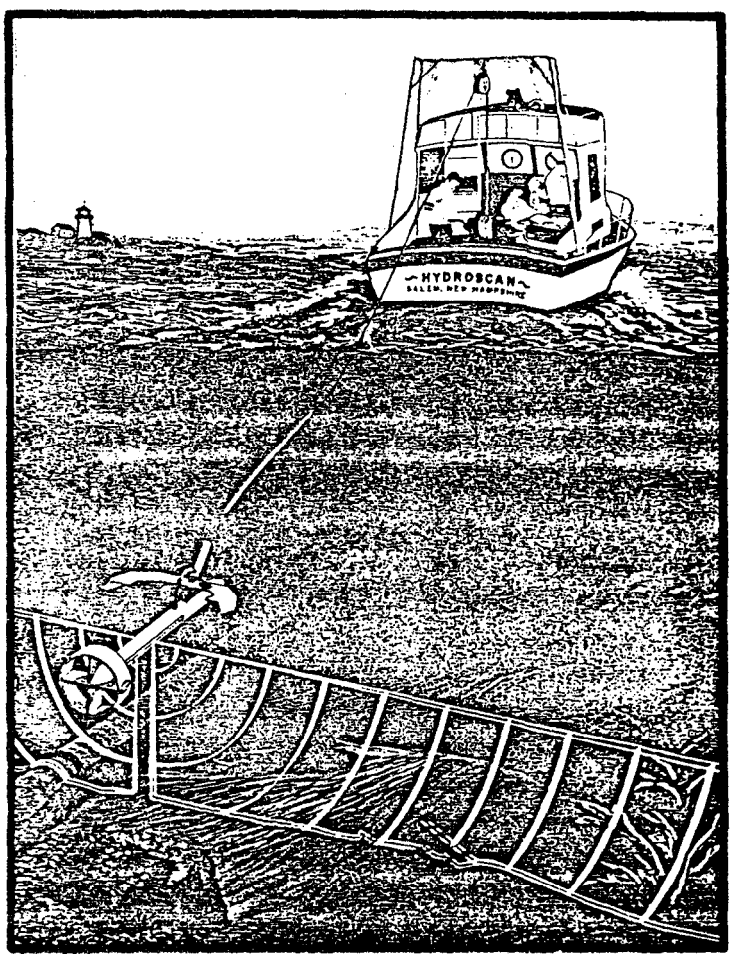

Figure 1. Side-Scan Sonar Technique
(Courtesy of Klein Associates, Inc.)

U. S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center
P. 0. Box 631, Vicksburg, Mississippi 39180

A typical SSS system consists of a pair of transducers mounted in a cylindrical body or "towfish" and a dual channel recorder connected by a conducting cable (Figure 2). The recorder's control section triggers the signal sent by the "towfish." After a length of time determined by the-distance the sound must travel, the signal is received and is printed as a darkened area by the recorder. Most SSS systems manufactured today operate at one of two frequencies, 100 kilohertz (kHz) or 500 kHz. The l00-kHz system normally is used for locating objects and mapping the seafloor because the lower frequency travels farther in water, covering a larger area.. The 500-kHz system should be used for inspecting underwater structures since the higher frequency sound waves allow better resolution of detail.

INSPECTION METHODS: Normally, inspection of structures with SSS is done from a boat. Inspections should not be attempted where waves are higher than about 2 feet because the wave motion is transmitted to the "fish," producing a smeared image. If wave heights are no greater than a foot, boats from 16 to 25 feet long are stable enough to operate effectively. However, larger boats are needed when waves are higher, and boats from about 40 to 50 feet long would be required if waves were near 2 feet high.

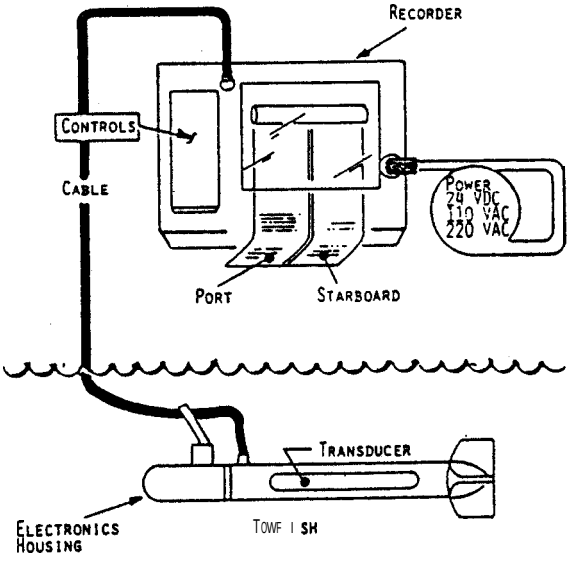

Figure 2. Typical Side Scan Sonar System
(Courtesy of Klein Assoc., Inc.)

The towfish can be connected to the boat's bow or amidships; however, towing from amidships works better. Less of the boat's pitching motion will be transferred to the fish, and the position of the fish in the water can be more accurately controlled. Towing the fish over the stern is not recommended because the cable can get tangled in the propeller.

A positioning system accurate to within a few feet is required to accurately locate the features recorded on a SSS printout sheet. Positioning can be taken from horizcrtal control marks at regular intervals, about 100 feet, along a coastal structure. The marks need to be visible from the

boat being used for inspection. The SSS printout will be marked as the boat moves past positioning marks or other features on the structure which can be used as reference points. Then,' if the boat is moving at a known constant speed, the locations of any structural features of interest as shown on the record sheet can be determined.

The recommended range of towing speeds is from one to two knots. The clarity of the record increases as the towing speed decreases.

SSS can be used to inspect both sloping structures and vertical structures. Generally, inspection of vertical structures such as seawalls requires more detail since features of interest are usually smaller (i.e., cracks and misalignments) than those on a sloping structure such as a rubble-mound structure with large armor units. For inspecting vertical walls where small features need detection, the fish should be.boat-mounted so it can be moved vertically without rotation or horizontal motion. The boat should be kept as near motionless as possible (i.e., tied up to the wall) and the fish fixed to a rod mounted in a rigid frame. About a 50- to 100-foot length of wall can be surveyed in a few minutes by lowering and raising the rod from this fixed position. Raising and lowering the fish is not recommended for sloping structure inspections because of extreme distortions on the printouts.

Vertical surveying, where the fish is turned upright and moved vertically rather than in the normal horizontal direction, will give more detail of vertical features. However, this is a specialized technique which has not been widely used. Further research is needed to better quantify its direct applicability to solving engineering problems.

SSS inspection from land may be possible when there is adequate access to the water. The frame can be hung from the side of a truck which is driven along along the structure to be inspected. The main advantages of this land-based system compared to a boat are the significant reduction in survey time and the increase in accuracy due. to better stability of the fish.

INTERPRETATION OF SIDE-SCAN SURVEY RECORDS: Some people expect a SSS record to look like an aerial photograph; however, it does not. A detailed explanation of how to interpret SSS records is beyond the scope of this technical note. Basically, thinking of the SSS beam as a flashlight in a dark room and the oblique image shadow as your printed record will give the proper perspective for viewing SSS images. The darkness of the printed image is a function

of the material type and the structure's side slope. Reflected sound from steel produces a darker image than from concrete or stone, but concrete or stone produces a darker image than wood. Coarse materials show up darker than fine materials such as sand. Also, the more nearly perpendicular the surface is to the sound wave, the stronger the reflected signal and the darker the image. A projection from the sea bottom, such as a displaced armor stone, will show up as a dark area with a white area behind it because no signal is reflected from the shadow. The ocean bottom will show up as a lighter area.

To produce good-quality records, an experienced SSS operator is a necessity. Prior knowledge of the kind of structure being inspected makes interpretation much easier. Fortunately, drawings are available for most coastal structures. With experience in interpreting SSS records and a knowledge of what the structures originally looked like, such things as changes in slope and material composition, stones and armor units displaced beyond the toe, and holes or cracks in the structure can be identified on the SSS records.

Divers should be used following the initial SSS inspection. With a good positioning system, divers can return and make visual inspections of the areas where questionable images are found. The advantage of combining SSS and divers is that the diving operation can be reduced at a cost saving. Divers need to inspect only a small percentage of the total length of the structure. SSS may be the only tool needed in future inspections unless new problem areas are found. Less diver verification will be required as experience is gained in interpreting the SSS records.

AVAILABILITY: Several SSS systems which could be used for inspecting coastal structures are available for use within the Corps. CERC has a 500-kHz system with a sub-bottom profiler and is discussing using the system for inspection work with several Corps Field Offices. CERC's contact is Jim Clausner (601) 634-2009. Most of the following systems are being widely used so it is recommended that a lead time of six months or more be allowed when requesting their use, The Mobile District has a 500-kHz system and extensive experience using it for inspecting coastal structures. Their contact is James Reaves (205) 690-2704. Other Corps offices with this type of SSS system include: Philadelphia District, contact Bob Wagner (215) 365-5034, and Little Rock District's Resident Office at Pine Bluff, Arkansas, contact Duane Combs (501) 534-0451.

A number of commercial firms lease 500-kHz SSS equipment.

ADDITIONAL INFORMATION: Contact Jim Clausner, Prototype Measurement and Analysis Branch (601) 634-2009 (FTS: 542-2009).

REFERENCES:

FLEMING, B. W., "Side Scan Sonar: - A Practical Guide," International Hydrographic Review, Vol. 1 III, No. 1, Jan 1936.

PATTERSON, D. P., SHAK, A. T., and CZERHAIK, M. T., "Inspection of Submerged Arctic Structures by Side Scan Sonar," Paper 4224, 14th Annual Offshore Technology Conference, Hay 1982.